Prepared For:

Yukon Government

Assessment & Abandoned Mines

Ministry of Energy, Mines and Resources

FARO MINE COMPLEX

SITE-WIDE ELECTRICAL ASSESSMENT

INTERIM REPORT

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1. EXECUTIVE SUMMARY

Struthers Technical Solutions Ltd. (StruthersTech) has been contracted by the Yukon Government to perform a site-wide assessment of the electrical infrastructure at the Faro mine site.

Two StruthersTech engineers, Mr Christopher Struthers and Mr Aaron Lake, were dispatched to the project site from August 23rd through 26th 2016 for the initial field inspection. The purpose of this trip was to gain familiarity with the site, install temporary power monitoring equipment and take detailed notes and records to plan a more comprehensive field inspection in September 2016.

The purpose of this interim report is to convey the initial findings from this first visit, especially with regard to safety, and to provide direction and focus for the remainder of the assessment contract.

Key findings with respect to safety are as follows:

- A large number of contraventions of Canadian Electrical Code were noted across the site. Given the history and the present capabilities of the site it is not feasible to correct all of them immediately.

  We have listed them in this report and will discuss the risks and priorities with YG in due course. Significant items that should be attended to at the earliest practical opportunity include the following:

  - Purchase portable grounding mats for electrical workers to use when performing overhead 4160V switching. The existence and/or condition of the permanent ground mats is highly questionable.
  - Schedule the replacement of the severely cracked wood pole supporting the transformers at the Intermediate Pond. This pole is at elevated risk of failure, especially if exposed to high wind loading.
  - Wherever quick-connect mining cable couplers are used, immediately apply padlocks to those couplers that are not already locked. Schedule all of these for replacement with hard-wired cable terminations at the earliest convenience.
  - Prepare sensitive ground-fault protection devices for submersible pumps at the Grum Pit and Groucho Pond.
  - Red-flag the rear entrance to main Faro Substation E-House #1 on both sides, to prevent personnel being exposed to the rare but real possibility of a step and touch shock hazard where standing water and non-compliant soil conditions are present. Eventually plan to apply code-compliant clean insulating gravel in this location and others.
  - Schedule the installation of an additional guy-strain insulator for the 4160V fuse drop at the Faro pit pumping station. There is an elevated risk of shock in the event that a vehicle hits the guy-wire on this pole. The installation of concrete no-post or lock-block barriers around the existing guy- wire anchor would also be an acceptable and straightforward fix at this time.
  - Have the site electrician replace any non-compliant extension cords or extension-cord fittings that are presently in use. Plan to replace temporary extension cords with more suitably protected hard-wired permanent cabling for stationary loads that are to continue operating beyond the current year.

- The present Care and Maintenance Contractor has a pro-active attitude toward electrical safety and is making continual improvements at the site in this regard. In this report, we have identified some additional suggestions, including additional safety equipment (Arc suits with cooling fans, portable grounding mats).
- Given the state of the electrical network, we recommend increasing the on-site presence and availability of qualified electrical worker(s). There is no shortage of electrical work to be done.
    - Any spare time the electrician(s) have could be applied to repairing non-compliances or decommissioning unused electrical equipment from the system.
    - Having more consistent coverage by qualified personnel will provide improved response times and higher levels of safety in the event of electrical failures, system changes or emergency situations.

Recommended course of action for the return visit to site, scheduled for the week of September 12th:

- Continue inspection and testing of ground-grids at a number of high voltage transformer locations. This will include limited digging in some locations (150mm depth) to verify the existence and condition of grounding mats and ground rods.
- Finish a comprehensive survey of the 69kV transmission line to Van Gorda. Each and every span will be measured and documented for line to ground clearance, whether or not brushing of vegetation is required, and inspected for general compliance with code.
- Finish a comprehensive survey of all 4160V overhead disconnect switches and document which ones are equipped with insulating rods and those that are not.
- For Discussion: Our technologist can perform testing of the 4160V relays and circuit breakers during the visit, if required. However, this work will require an outage on each circuit and may be better scheduled for the winter season when critical pumping operations have ceased.
    - Inspection and testing of spare circuit breakers not in service could be performed without an outage.
- Finish a comprehensive survey of electrical spare parts and equipment, particularly with regard to 4160V switchgear and spare transformers.
- Take oil samples from all large transformers, and send these samples for laboratory analysis. Samples will be tested to detect internal transformer condition and the presence of PCB's. (Hazardous waste)
- Download all of the metering records for the past few weeks. Shift the portable meter from the Faro pump station to the Miller Skid to determine an accurate load on this pump. Disconnect temporary meters and demobilize them from the site.
- Make an inventory and identify locations of all wooden poles on un-used circuits (particularly on the Van Gorda side) that are in good condition and may be re-used for future line works.
- Note that the mobilization of an electrical bucket-truck (subcontractor) is not required for completing our engineering scope of work. Using a telephoto zoom lens, we have been able to perform any overhead inspections that are required.
    - We will be recommending a number of overhead fuse replacements. If this work is carried out within our scope, it may be executed at a later date as convenient for the C&M contractor onsite. Our engineers' are not required to be present.

Additional office-engineering tasks to complete the contract scope of work are suggested below. We will be calculating the budget spent to date, the budget required for the return trip to site and a budgetary estimate for the following tasks. Completion tasks to be approved subject to consultation with YG.

At this time, we feel that most or all of the following tasks will be achievable within the existing budget:

- Assist the C&M contractor with updating their electrical Safe Work Procedures.
- Build a more accurate ETAP power system model of the site network. The ETAP model will be used to perform the following:
    - Provide a more accurate estimate of network losses across the site, and where they are occurring. (We have identified around 160kW of 'missing' power on the Faro Pit and Van Gorda network, and we suspect that transformer and transmission losses are major contributors.)
    - Review protection co-ordination curves and make changes to relays and fuses for improved safety and reliability.
    - Re-calculate arc-flash hazards in all major active load centers, using the recommended fuse changes and relay setting adjustments.
- Provide analysis and recommendations for making improvements to the site-wide grounding systems, including code-compliant upgrades for the ungrounded 69kV transmission line and various 4160V generator-supplied step-up transformers.
- Provide justification for removing the T3 4160:4160V transformer from service.
- Minor updates to the topographical electrical mapping drawings, and re-drafting of the site single line diagrams.
- Provide recommendations for optimizing the number and location of diesel generators for emergency backup power at the site.
- Perform a design feasibility assessment and cost estimate for a 230m long 69kV span that would allow the excavation of the Rose Creek bypass through the Van Gorda haul road.
- Provide basic design and costing of an outdoor overhead replacement for the electrical power to the Miller Skid, allowing the electrical equipment inside the old workshop to be decommissioned and/or demolished.
- Follow up with Yukon Energy on the state of the main 138kV substation.
- Provide capital cost estimates for various options for the main substations over the next 10-15 years:
    - Options for decommissioning or modifying the two 69kV substations and 69kV transmission line.
    - Options and justification for decommissioning the obsolete main E-house's at the main Faro substation.
    - Options and justification for decommissioning the obsolete E-house at the Van Gorda substation.
    - Options for complete re-location of the main 138kV Faro substation.

  - Options for powering the Van Gorda site from a new 138kV substation and the economics for running this site from diesel generators for the limited number of summer months that it is active.

- A brief assessment on the feasibility of renewable power at the site, with high-level suggestions for some more financially attractive options for improving energy-efficiency. Options will include:
  - High efficiency LED-lighting
  - Photocell control of outdoor lighting.
  - Thermostatic regulation of parking-lot vehicle heaters in winter.
  - Consideration of energy recovery turbines on gravity-fed water pipelines.

We look forward to continuing with the remaining phases of this project, and would like to thank the Faro mine site and Yukon Government personnel for their co-operation to date.

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2. ELECTRICAL SAFETY – GENERAL OBSERVATIONS

The Yukon Government has made it clear that the assessing and prompt reporting any electrical safety concerns be the highest priority item within this contract. Accordingly, much of the focus of this interim report is dedicated to safety items.

While reviewing the findings contained herein, it is important to recognize the context of the mine site. Following the bankruptcy of Anvil Range Mining Corporation in 1998, the site fell into a state of neglect and disrepair for many years.

More recently, under the management of the Yukon Government (YG), the site has begun to repair and maintain the critical parts of the electrical infrastructure. Much more work needs to be done and many non-compliances to Canadian Electrical Code and/or Yukon Workers Compensation Health and Safety Board (YWCB) still remain.

Immediate compliance for all areas of the site is simply not feasible, but positive forward progress is being made. One of the main purposes of this contract is to assist YG with prioritizing the necessary repairs, upgrades and replacements.

2.01. ELECTRICAL SAFE WORK PRACTICES

Parsons, the present Care and Maintenance contractor, has a positive attitude towards safety on the site and is in the process of modifying and improving the various safe-work practices and procedures in use.

- Lock-out / tag-out procedures are in place, well organized and with the necessary padlocking + tagging equipment readily accessible to workers. We witnessed multiple instances of workers correctly applying lock-outs while performing their tasks. This is being done well.
- Electrical Safe Work Practices (SWP's) documented by the previous C&M contractor are generally in accordance with CSA Z462 standard "Workplace Electrical Safety". Some minor improvements could be made as Parsons' develops the updated versions. We would be happy to assist Parsons' with these updates as part of our assigned scope:
    - There are a few minor inconsistencies and/or unnecessary repetition between the various SWP's.
    - More specific material related to overhead lines, fuses and switches should be included in the SWP's. We recommend adding procedure for the use of temporary grounding mats when performing overhead switching, due to concerns about the quality and integrity of the existing mats in a number of locations. (Refer to ground mat concerns later in this memo).
    - Some updates required to reflect the latest (2015) version of CSA Z462, which has simplified a lot of issues related to Arc-Flash labelling and Arc-Flash PPE.

2.02. ELECTRICAL PERSONNEL

- Electrical contractor, Jay Sather of McLeod contracting, appears to have good knowledge of safe working practices for high voltage systems, including switching of overhead lines. We did not check his exact qualifications and training, but these could be requested via his employer.

- Given the generally poor condition of the electrical equipment at site, we recommend that the site have electrical personnel with high voltage training available at site on a more frequent basis.
- In particular, when Jay Sather or a similarly skilled electrician is not available, alternative personnel must have basic training for shutting off the power systems in the event of an emergency.
    - Parsons' have informed us that Len Faber has the appropriate training for this type of event, but we did not have the opportunity to verify his qualifications or experience.

2.03. ELECTRICAL SAFETY EQUIPMENT

- Adequate electrical safety equipment is available to Jay and Others at site.
- Lock-out / tag-out equipment is readily available and well organized.
- Hot-sticks, hot-gloves, grounding-sets and voltage detectors are generally in good condition, bearing recent test certifications.
- Jay Sather wears low-level arc-resistant clothing each day (between 8 – 12 cal/cm2), which provides adequate coverage for most low-power electrical equipment at the site.
- Arc-flash suits are available, but some improvements could be made:
    - Recommend having additional (larger) sizes available.
    - Recommend equipping the suit(s) with air-flow fans. Without air-flow fans, workers quickly become overheated and the viewing shields become foggy. This creating additional working hazards and increases the likelihood of mistakes. The additional discomfort can result in workers cutting-corners to avoid using the PPE when it is required.
    - At least one flash suit was in need of repairs.
- We recommend that site purchase temporary ground-mats for use when performing overhead switching operations. (Refer to later section on grounding at overhead switches).

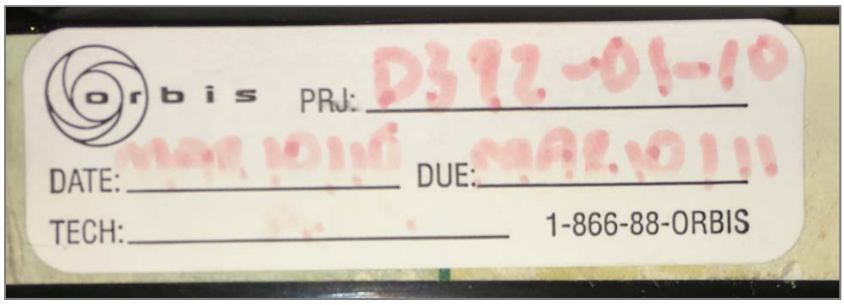
2.04. ARC FLASH STUDIES AND ARC FLASH LABELS

- Several spot-checks on the 2016 arc-flash calculations by EA Nunn revealed a number of inconsistencies. While it is expected that different engineers' will have some variations in their approaches and results, we found some significant anomalies that require further analysis.
    - For example, all low voltage cables and much of the overhead line impedances were omitted from the study. The author(s) have wrongly assumed that this provides a more conservative assessment of the arc-flash results, but this assumption is often invalid.
- We will re-calculate the hazard levels for some of these problematic areas, and can do so within the allotted project budget. New calculations will take into account the replacement fuses that we will be recommending.
- Once we have done so, the issue of new arc-flash labels can be addressed. Many labels found on site were from an earlier study by Orbis Engineering, and a number of results are quite different from the more recent study performed by EA Nunn.

3. ELECTRICAL SAFETY – SPECIFIC PROBLEMS IN NEED OF ATTENTION

3.01. PROTECTION RELAYS AND 4160V CIRCUIT BREAKERS

- Protection relays (and likely the Circuit-Breakers) have not been tested since 2011. Testing is now past due, especially given the age and condition of this equipment.
- StruthersTech is able to perform this testing during our next visit to site, subject to the practicality of taking a power outage on each 4160V circuit.
- If an outage is not practical, this work could be postponed until the winter season and performed by any suitable contractor when the water treatment processes are more easily interrupted.



The most recent testing labels found onsite were applied by Orbis Engineering in March 2011.

3.02. PROTECTION RELAY SETTINGS

- Protection relay and adjustable breaker settings are not set for the present site loadings and are not optimized for safety. We will be performing some basic calculations and can recommend the new settings within the existing project budget.

3.03. NEUTRAL GROUNDING RESISTORS

- Many 600/347V neutral grounding resistors are in use at the site, but they are un-monitored and are not equipped with automatic ground fault tripping. This allows ground-faults to persist undetected, elevating the risk of a subsequent phase-fault.
- Canadian Electrical Code specifically requires automatic tripping or alarming for ground faults on an NGR system.
- We will be recommending some options for correction in the final report. For now, these problematic identified areas are as follows:
    - Interim wastewater treatment plant.
    - Groucho Pond
    - Grum Pit
    - Little Creek
    - Van Gorda “Swimming Hole”

- Main Van-Gorda substation 4160V system. (SE-135 feeder protection was spotted; NGR monitoring may exist but was not identified – flag for follow-up.)
- Backup generator at Faro Pit does not have the Wye-point grounded, it is floating. It feeds a step- up 600V delta to 4160V delta transformer, the nameplate for which is not visible. This results in non-compliant grounding of both the 600V and 4160V systems when the generator is operating. (Ungrounded systems require ground-fault detection).

- Other possible non-compliant grounding arrangements were noted at these locations:
  - The step-down transformer at Norcan shop is configured with a Delta primary. This means that the 4160V system is ungrounded when the 600V standby generator is back-feeding into the line.

3.04. GROUNDING OF 69KV TRANSMISSION LINE

- The 69kV transmission line between Faro and Vangorda is completely ungrounded. The 69kV windings on the step-up and step-down transformers are both Delta-connected. This means that ground-faults on the 69kV line will persist undetected until they self-clear or propagate into full blown phase to phase faults.
- Canadian Electrical Code requires all ungrounded power systems to be equipped with ground fault monitoring, but no monitoring systems are in place.
- We will perform some further study to better determine the risks of this design, but suspect the following problems may be present:
  - Undetected ground faults will cause excessive line-to-ground voltage stress on the unfaulted phases, putting them at increased risk of insulation failure and subsequent flash-over. This is particularly concerning with regard to the two large transformers.
  - Undetected ground faults that result in persistent or intermittent arcing to vegetation or structures may result in an elevated fire risk. Intermittent arcing can also result in extreme voltage stress on the unfaulted phases.
  - Circulating line-charging currents that may be present during an undetected ground fault could cause step and touch shock hazards to workers. We have not yet performed the calculations to determine the magnitude of this risk but it needs to be checked.
- Note that the 69kV system has been in operation since the early 1990's. Despite the non-compliance with present codes, it may be that the design of the time was adequate for the purpose. It may also be that only good luck has resulted in functional operation over the past two decades. To be studied further.

3.05. INSULATING GRAVEL AT SUBSTATIONS, BONDING OF FENCES, GATES AND HANDRAILS

Canadian Electrical Code requires a layer of high-resistivity crushed gravel to be spread on and around high voltage substations and outdoor high voltage switches.

Virtually every such location at the site is non-compliant in this regard. Accumulation of fines, mine waste and vegetation has the severely degraded the integrity of this insulating layer. Of particular note, the rear entrance door to main substation E-House #1 is surrounded with standing water containing high mineral content from the mine waste.

We also noted deficiencies on the bonding of fences, gates and handrails at all of the older installations at site. Connections have loosened, bonding conductors have been damaged or are missing at numerous locations.

This puts workers at an elevated risk of step and touch voltage shock in the event of a high voltage power system fault. The risk is low, given the very limited amount of pedestrian traffic around the substations, and the very low likelihood of a high voltage fault occurring at any given time. Accordingly, we recommend the following:

- Any substation that is to remain in service should have the top layer of accumulated fines excavated and removed. (In some instances, it may be acceptable for the fines to remain).
- Plan to spread up to 200mm of clean insulating gravel in each high voltage substation yard, and extend this to 1.5m outside of the fenceline(s).
- Have an electrician check and reapply where necessary, bonding jumpers at all fences, gates, metal stairs and handrails around high voltage substations.

Conditions inside the main 138kV YEC substation are not as bad as other areas, but we recommend it could use an overlay of fresh insulating gravel.

Soil conditions around the T3 isolation transformer are non-compliant.
Recommended solution is simply to remove T3 from service as soon as practical.

Soil conditions and standing water around the back of the 138kV substation are non-compliant, particularly at the rear entrance to E-Room #1. Given that the front door access is available, an immediate short-term solution is to red-tape and post notices at this entrance on both sides of the rear door.

The 69kV Step-Up Station requires a fresh layer of insulating gravel for code compliance.

The 4160V step-up transformer at the Faro Pit standby generator appears to be compliant with a 4-rod grounding grid and a layer of relatively clean gravel spread around it…

… but the grid and gravel do not extend around the 600V generator that is electrically tied to the HV transformer. Shown here, the access steps and handrails to the generator enclosure are in standing water and do not appear to be directly bonded to the station ground.

4-Rod ground-grid and clean gravel spread at the 4160V Faro Pit pump station are done well.

Soil conditions at the 69kV Repeater Station Tap-off are not bad, but vegetation removal is recommended.

The Van Gorda 69kV step-down station requires vegetation removal and some fresh gravel. The nearby "remote grid" should also have vegetation removal and fresh gravel around the fenceline perimeter.

Some vegetation removal and clean gravel required at the 4160V Little-creek Transformer Station.

3.06. GROUND GRIDS AT 4160V STEP-DOWN INSTALLATIONS

For sites such as Faro that are required to follow the Canadian Electrical Code (ie, are not granted a Utility exemption by the authority having jurisdiction), the ground grid at each and every high-voltage installation – including the overhead pole-top transformers – is required to meet certain minimum requirements, including the following:

- Consist of a minimum of four ground rods.
- Be interconnected with minimum #2/0 copper conductors, between 150mm to 600mm depth.
- In most cases, require >=150mm layer of insulating gravel to placed on top of the ground grid and extend 1m from any fence-lines.

Most pole-top installations inspected did not appear to comply with this requirement.

We will be providing a list of options and recommendations for overhauling the site-wide grounding systems in our final report.

3.07. GROUND MATS AT OVERHEAD LINE SWITCHES

The existence and/or condition of the required ground-mats below the overhead line switches is questionable. While some of the newer installations show signs of the ground-mats being installed correctly and in good condition, others do not:

- We suspect that ground mats are missing from some locations.
- Some ground mats are visibly damaged and/or disconnected.
- Ground mats are required to be installed on clean insulating gravel, and either be exposed or covered by a maximum of 150mm insulating gravel.

We recommend that site purchase one or more temporary grounding mats that the electrical workers can connect and use when performing switching operations, until the condition of each grounding mat can be verified and/or repaired to an acceptable state.

On our return trip to site, we plan to actively dig around the poles/switches to inspect each and every ground mat at the site.

Clearly damaged and non-compliant ground-mat below an overhead 4160V switch.
Located nearby the Miller Skid.

3.08. CONNECTION OF OVERHEAD NEUTRAL CONDUCTORS TO GROUND RODS

Best practices require that the overhead ground/neutral conductor on a high voltage distribution system be connected to a ground rod, maximum every 400m, to prevent induced voltage build-up from the primary conductors. We found multiple instances where the 400m distance between grounds was exceeded.

We will be providing a list of options and recommendations for overhauling the site-wide grounding systems in our final report.

3.09. OVERHEAD FUSES

Many of the 4160V fuses are considerably aged with their identifying labels decayed or missing. With the telephoto zoom lens we were able identify the sizing of any fuses with intact labels, and have documented those fuses without.

A spot check of some of the fuses have confirmed improper sizing that is non-compliant with the Canadian Electrical Code. Additionally, many of the arc flash hazard levels calculated by EA Nunn are based on assumptions of fuse sizes that are likely quite different. EA Nunn had assumed “Kearney” general purpose fuses

throughout the site, whereas documentation found in the old electrical office shows that the site had likely been purchasing only Chance type “C” and S&C fuses.

Additionally, many of the fuses are mounted in aged porcelain fuse holders. The line contractor and site staff have expressed concerns over the safety and reliability of these holders, as failures have been experienced in the past. Failure of a compromised fuse holder during live disconnection by a worker is a significant safety hazard. (Arc flash, shattering porcelain with projectiles)

With the above points in mind, we will be producing a list of recommended replacement fuses and holders for operating locations that could be changed by an overhead line contractor.

These fuse replacements do not need to be co-ordinated with the return to site of our engineers, and could be scheduled at any convenient time with the C&M contractor.

Left: This 100A S&C Type XS fuse is improperly sized for the 225kVA transformer at the Van Gorda WTP

Transformer rated amperage at 4160V is just 31A, code allows a maximum standard fuse size of 50A. The oversized fuse results in excessive arc-flash hazard on the 600V side of transformer due to slow clearing time.

Right: Typical 4160V aged fuse & porcelain holder. A number of these should be replaced with new fuses in polymer insulated holders. Having known documented fuse sizes allows for certainty in the arc-flash calculations.

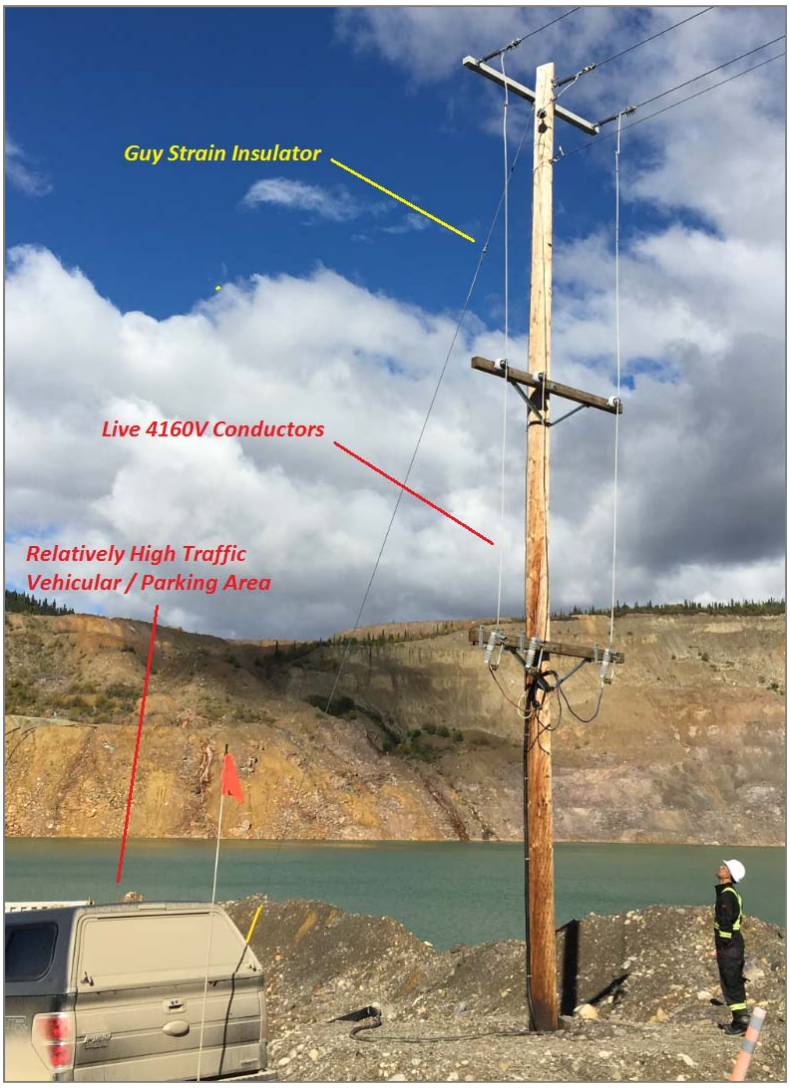
3.10. IMPROPERLY INSTALLED GUY STRAIN INSULATORS

Guy wires that provide support to the overhead poles are required to have an in-line strain insulator, such that an accidental contact between the live wires and guy wire does not result in an energized guy at ground-level.

The insulators are to be installed at an elevation lower than any live parts, in order to be effective for the foreseeable instances of possible contact.

A number of locations at the site have the guy-strain insulators improperly installed at an elevation higher than the live phase conductors, rendering them ineffective in the event of a phase-to-guy contact.

Of particular concern is the installation at the Faro pit pumping station. This one presents a higher risk than most as the guy-anchor is located directly adjacent to a vehicle parking area.



Improperly Installed Guy-Strain Insulator at Faro Pit. The 5kV fuses have been installed at a low elevation for convenience, but this causes additional risk of Phase-to-Guy contact if a vehicle hits the guy-wire. Recommend adding another guy strain insulator at lower elevation and/or raising the 5kV fuses. Concrete no-post or lock-block barriers could also be placed around the guy-anchor for an immediate improvement.

3.11. ACTIVE POLES IN NEED OF REPLACEMENT

Generally speaking, the majority of the wood poles at the site are in good or fair condition. On the Van Gorda side, there are a great number of poles in good condition that are unused and may be decommissioned and re-used elsewhere where required. Green colored poles, in particular, are typically less than 15 years old and tend to be in the best condition.

We spotted two poles however, that should be replaced at the earliest convenience:

This pole, one span upstream of the Faro pit pump is heavily loaded due to the angle of the two lines. It is one of the older poles on site (1970's vintage) and is showing clear signs of rot and spiral fractures. It should be slated for replacement as it is not expected to last another 10 years.

This relatively new pole at the Intermediate Pond supports the 3 x 167 kVA pole-top transformers and is heavily loaded to the design limit of it's class. A severe crack (>25mm wide) has appeared in the pole and extends almost the entire length. The crack is too large for in-situ repairs (split-bolting) and we recommend the pole be replaced at the earliest possible opportunity. The crack has likely occurred due to improper drying of the pole after treatment by the pole manufacturer, in combination with the heavily loaded application.

3.12. OVERHEAD GANG SWITCH OPERATING SHAFT INSULATORS

A number of gang switches were observed to have no insulation between the control handle at the bottom of the switch and the upper portion of the switch near the operating blades. This is an important safety feature offered by manufacturers that insulates the operator from the upper portion of the structure in the event of a blade malfunction or a jumper wire making contact with the pipe that leads to the control handle. The location and recommendation of where to add insulating rods to the gang switches will be submitted in the next report.

3.13. NON COMPLIANT USE OF QUICK CONNECT MINING COUPLERS

Quick-connect mining couplers used on trailing-cables are a very convenient method for connecting mobile and portable electrical equipment. Their use is governed by CSA M421 “Use of Electricity in Mines”, and they are typically not permitted outside of an active mining areas.

A number of these cable couplers are in use at site, but they are not being used in a compliant manner with the required system ground-fault / ground-check protection devices. Code also prohibits the direct connection of a trailing cable with coupler directly to an overhead line.

Some of these couplers have been pad-locked to prevent disconnection under load, but some of them have not. Site electricians are aware of the requirements to switch off the load before opening the plug, but the risk is still there. Disconnecting a live 4160V plug presents a severe arc flash and electrical shock hazard.

We recommend the immediate application of padlocks to all couplers as an interim measure, and replacement of these plugs with hard-wired connections at the earliest practical opportunity.

Direct connection of 4160V trailing cable couplers to overhead lines are one of the more serious code infractions noted at the site. These couplers at the Van Gorda pump station are padlocked to reduce the risk of disconnection under load but are still non-compliant.

Outgoing 4160V connectors to the Van Gorda pumps are also non-compliant, as the upstream ground-fault / ground-check relays are out of service.

Backup Generator at the Norcan Shop uses a mining coupler without adequate ground-fault / ground-check protection. At 600V it presents a lower risk but is still non-compliant.

3.14. GROUND FAULT DETECTION ON SUBMERSIBLE PUMPS

Canadian Electrical Code requires that submersible pumps be limited to 150 volts line-to-ground, unless the site Owner has applied for a variance and the equipment is operated and maintained by competent electrical staff.

Code also requires that the electrical systems for these pumps be equipped with sensitive ground fault detection and tripping.

We found two submersible pumps on site that operate at 600V and appear to be non-compliant with respects to the ground-fault detection.

The Grum pit pump is fed from a 5A neutrally-grounded 600V system, but there is no ground fault protection at the resistor or inside the pump starter enclosure.

The Groucho Pond pump is also on a 5A neutrally grounded 600V system without ground fault protection. There is an MGFR ground fault relay in place, but it is out of service.

Although the electrical terminals of the Grum pit pump are above water, the rest of the motor / pump combination are below water and therefore classified as a submersible pump requiring sensitive ground fault detection. We will need to take a short outage of the pump to inspect the interior of the motor starter, and confirm if this protection is present.

Ground Fault Relay at Groucho Pond is Out of Service

3.15. FAILED TRANSFORMERS AT GUARD-HOUSE PARKING LOT

Shortly before our arrival to site, staff had detected a ground fault condition on the vehicle-heating panels at the main entrance parking-lot. Grounded panels felt live to the touch (tingling sensation), and the 4160V step-down transformers were disconnected to eliminate this hazard.

This near-miss incident reinforces the need for all of the grounding / bonding issues identified in this report to be dealt with.

The transformers in question have visible signs of oil leakage and surface tracking, and site staff had mentioned that these units have had custom-modifications to their bushings in the past.

Noting all of the above, we recommend replacing the transformers with tested units in good working condition. The old transformers should be disposed of, or sent to a professional transformer shop for repair and recertification. (We suspect that repairing these old units will not be economical).

Prior to disposal, the oil should be tested for Polychlorinated Biphenyls (PCB's), which are classified as a highly toxic hazardous waste in need of special handling and disposal.

3.16. TEMPORARY EXTENSION CORDS

- Temporary power cables ("extension cords") have been installed at the Interim Water Treatment plant to power a refurbished shipping-container enclosure.
- The un-armored cables are routed through standing water and utilize a male/female coupler combination that is missing the threaded outer ring. The coupler is sitting on an old chair to keep it out

of the water, but it is only one tripping hazard away from being accidentally disconnected under load and/or landing in the water.

- This poses an immediate safety hazard that is a simple item to fix if the correct materials are purchased. We recommend the following:
    - Route the cable (use another extension, if required) out of the way of pedestrian traffic, and out of the standing water.
    - Use a coupler with all of the correct fittings, such that the male and female plugs are locked with the threaded outer ring.
    - Couplers exposed to the outdoor elements should be on circuits with Ground Fault Interrupt (GFI) breakers and/or be tested regularly for assured-grounding.
    - If the shipping container is to remain powered for an extended length of time, the temporary cabling should be replaced with permanent cabling.

IWTP: Temporary (>1 week) Power Cable Routed Through Pedestrian Area in Standing Water

Cable Coupler is missing the Threaded Locking Ring

- A similar but less serious issue was noted at the Baker Tank at the Cross Valley Pond. Workers have used a male cord plug with a female wall-mount receptacle as the two fittings on an extension cord assembly.

If the Baker Tank is going to remain energized for an extended length of time, the extension cords should be replaced with permanent protected cabling.

Wall-mount Receptacle being used as an Extension Cord End at the Filter Station near the Int. Pond

3.17. ASSORTED MINOR ISSUES

- Some of the recently acquired electrical equipment, specifically the VFD pump controls for the Faro Pit and the Miller Skid, do not bear Canadian CSA (or equivalent) approval labels. They appear to have come from the USA and are technically not code compliant. The equipment is in good shape and the USA standards they have been built to are acceptable for the intended purpose, in our opinion. Does not pose a safety hazard but the non-compliance is noted and any new equipment should be required to have the appropriate Canadian approval labels.
- Condensation is visibly present inside the 600V main switch at the V15 pump station. The fuses are showing visible signs of active corrosion and should be replaced.
- The EA Nunn arc-flash report had correctly identified a range of problems with various 4160V fuses at the site. Some fuses are heavily aged in need of replacement, many fuses are unidentified with their ratings and suitability unknown. Other fuses are simply non-compliant with code. During our investigation, we have been able to determine the exact nature of some of these fusing issues.

  We intend to issue a list of recommended replacements within the next week.
- Junction-box cover is missing from the 600V entrance terminal at the Little Creek electrical room. Taped connections are exposed. The safety hazard is obvious and easily avoidable by the trained mine personnel, but a new cover should be arranged regardless.

600V Junction box with missing cover at Little Creek electrical room.

4. NOTED ENGINEERING AND DOCUMENTATION ISSUES

4.01. REVIEW OF RECENT ELECTRICAL DRAWINGS

While at the site we relied heavily upon the topographical maps of the electrical system that were produced by Associated Engineering in late 2015 to early 2016.

These maps are very well done and provide an excellent overview of the electrical infrastructure. We only found a few very minor updates to be made.

The electrical single-line diagrams however, could use some significant updating. We will be pleased to complete these updates within our assigned scope of work.

4.02. REVIEW OF ELECTRICAL EQUIPMENT INVENTORY

Associated Engineering had also produced an inventory list of all transformers, switchboards, large motors and fuses at the site.

Similar to the topological mapping, this inventory has been done well. Spot checks on the data agreed with most of our findings in the field, the exception being a number of the fuses. Using the telephoto zoom lens at site, we were able to capture some additional information that AE were unable to gather.

We will be updating the inventory list as necessary, with some additional information gathering planned for our return trip to the site.

4.03. REVIEW OF ELECTRICAL TESTING RECORDS

Very few recent test records were available at the site. YG is continuing to search the hand-over package from the previous Care and Maintenance (C&M) contractor and we will review any new information that is found.

Testing stickers on the equipment showed that Orbis Engineering were present at the site in 2011 and had performed a number of tests and inspections. We recommend that YG follow up with Orbis to receive a copy of these test reports if they cannot be found within the files of the previous C&M Contractor.

4.04. FOLLOW UP WITH YUKON ENERGY

During our first trip to site, we did not enter the 138kV YEC substation but were able to inspect a good deal of items from outside of the fence using the zoom lens on the SLR camera.

We have a number of questions and requests for information for follow-up with YEC, that should be initiated by YG:

- YEC to provide the most recent test and inspection documentation for all major equipment in the substation. Specifically:
    - The 138kV “transfer trip” grounding switch. Has the operation timing been tested recently?
    - Test reports for protection relays.
    - Any condition assessments, oil tests or electrical tests for the two main transformers.

  - Any inspection or test reports for the two 1000A neutral grounding resistors.
  - Any test reports for the ground grid.
- Specific details as to why T1 is out of service with grounds on the primary. Informal conversations at site suggest that the secondary 4160V busbars have a ground fault. YEC to confirm if the transformer itself is fit for service.
- Clarify YEC's jurisdiction on the 4160V secondary protection device(s). Specifically:
  - The main breakers on the 4160V switchgear, the site single line notes "Operated by YEC". Ask YEC to explain further. Is Faro permitted to make modifications to protection and control of this breaker?
  - What are the secondary protection elements that trigger the primary-side "transfer trip" grounding switch? And is Faro permitted to modify (add) to these elements?

5. ENERGY ANALYSIS

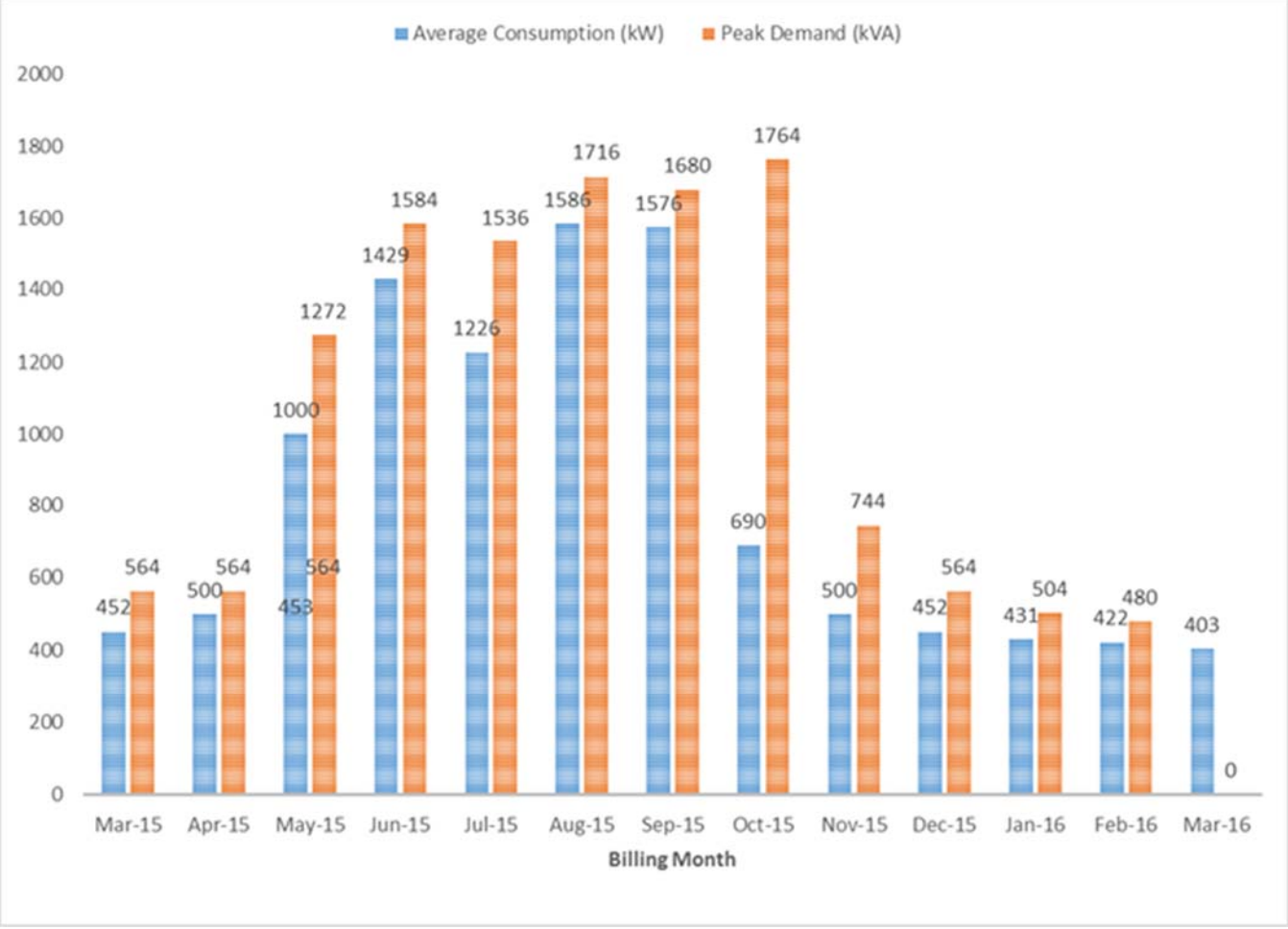
5.01. ANALYSIS OF YUKON ENERGY BILLS

Prior to arriving at site, we tabulated and plotted the last 12 months of billing data from Yukon energy. The results are shown on the following page. Key findings were:

- Very steady loading during peak summer months, with only a small difference between average round-the-clock kilowatts and peak kVA demand loading.
- Maximum peak load of around 1,700kVA (power factor unknown) with maximum average 24/7 power draw of just under 1,600kW.
- When taking power factor into account, this suggests that site loading during the summer months is extremely steady on a 24/7 basis.

It also shows that the present site loading is just a fraction of what the main electrical infrastructure is designed to handle.

Take for example, the system feeding the Van Gorda site, has transformers rated for 10,000kVA at each end. We will be performing some energy efficiency calculations to determine the cost of power losses in these oversized transformers.



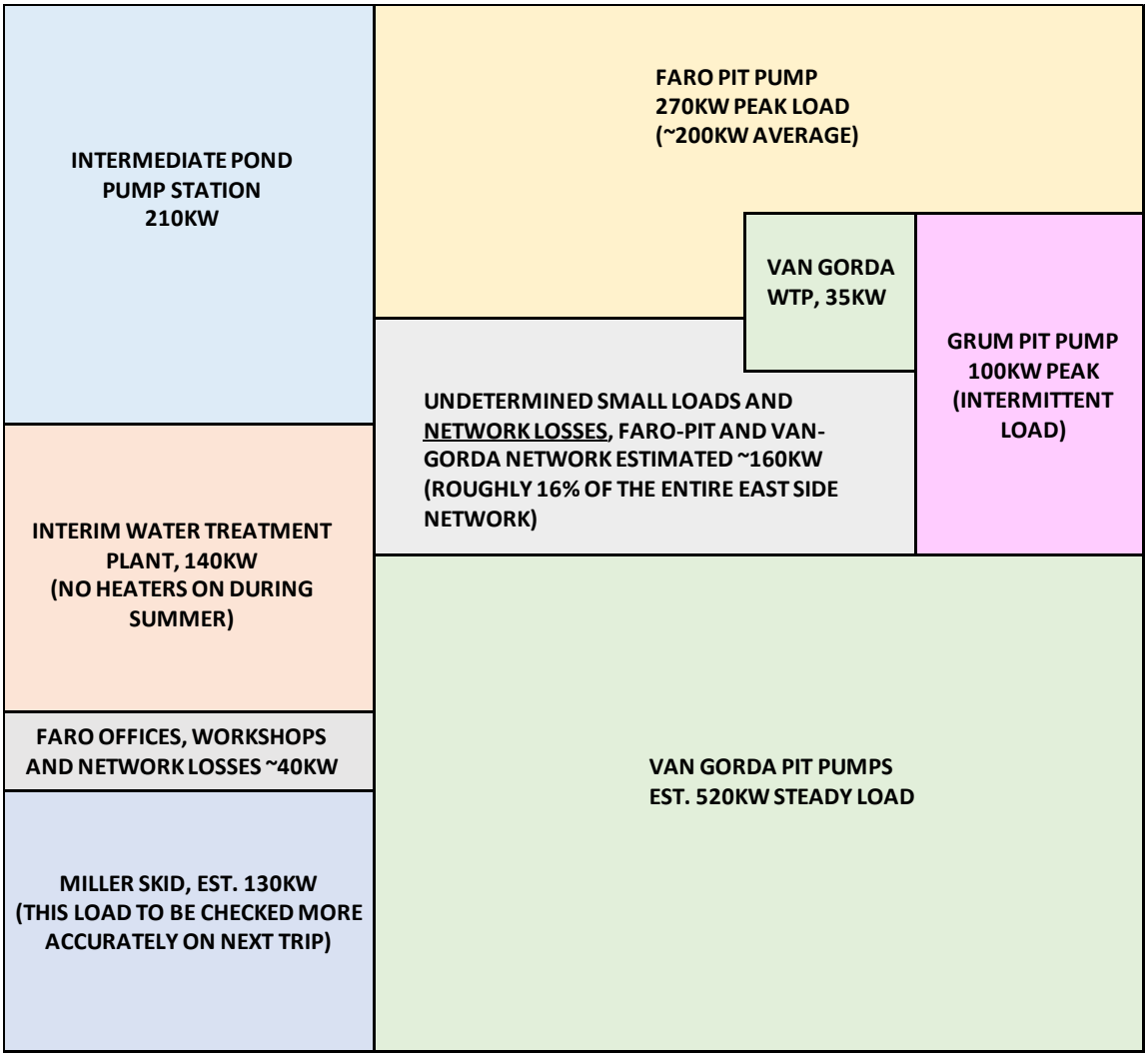
5.02. ONSITE METERING

Power recording meters have been set up at the following locations. Approximately 24h of results were downloaded while at site, with the next two weeks of recording to be collected on our second site trip.

- 4160V feeder to the West-side distribution, including the Miller Skid, office complex, Interim Water treatment plant and Intermediate Pond.
- 4160V feeder to the Faro Pit and Van Gorda site.
- Pumping station at the Faro Pit.

Combined with spot-measurements taken from in service ammeters and VFD drive displays, recording of major nameplates, we have been able to determine the breakdown of the peak summer power usage with fairly good accuracy.

A graphical representation of the peak loading is shown as follows:



Graphical Breakdown of the Peak 1,600 kW Site Load Measured on August 25th, 2016

“West Side” Network on the Left totals to around 500kW, with the remainder of the site load going to the “East Side” Faro Pit and Van Gorda site.

Note also the ~16% losses on the East side network. We suspect much of these losses are being incurred in the 3 large transformers and the 69kV transmission line. We will be performing some additional network modelling to quantify these losses further.

We will be requesting from YG the typical / expected turn-on and turn-off dates for each of the major loading centers. This will allow us to model a wider range of network scenario’s and load estimates for different times of the year.

6. GROUND GRID RESISTIVITY MEASUREMENTS

During our first trip to site, we took ground grid resistivity measurements at the following locations:

- Main 138kV Substation: Approximately 1.5 Ohms
- 69kV Step-Up Substation: Approximately 0.8 Ohms
- 69kV Step-Down Substation: Approximately 16 Ohms
- Remote Grid @ 69kV Step-Down Station: Approximately 5-6 Ohms*

Test results will be further analyzed with the related power system and grounding options that are being reviewed.

Further testing will be performed at the following major load or generation sites:

- *Re-testing of the remote grid at 69kV step-down station (due to inconclusive results).
- Intermediate Pond.
- Interim Water Treatment Plant.
- Standby Generator at Faro Pit.
- Standby Generator at the Interim Water Treatment Plant.
- Standby Generator at the Norcan Shop.
- Miller Skid.
- Faro Pit Pump

Note that the precise resistivity of any individual ground grid is difficult to determine, as the overhead ground conductors at many locations have not been terminated to insulators, with the required disconnecting link at the incoming structure bases.

The one location where this has been done correctly, at T3 4160V outgoing line, the disconnecting link is now buried under accumulated waste material.

Analysis of ground grid results will need to take this into account.

7. CAPITAL PLANNING

7.01. REPAIRS TO OVERHEAD LINE AT FARO PIT AREA

A large section of line around the Faro Pit has been taken out of service due to frequent faults. As a result, the Zone 2 and SIS Wells are being powered off temporary diesel generators.

The problem has been narrowed down to the following areas:

- Bundle type insulators being used on 7 spans, these are notoriously unreliable over time and especially during inclement weather.
- One long overhead span with insufficient phase-to-phase clearance. We suspect the phase to phase flashovers may be occurring during high wind and rain conditions.

A separate document has been produced with a basic scope of work for correcting these problems. Once the line is repaired, the diesel generators powering Zone 2 and SIS could be disconnected and the loads supplied by the network.

Bundled Multiphase Insulators used for 7 spans of Line near Faro Pit are Notoriously Unreliable

This long 4160V span near the Faro Pit has insufficient phase to phase clearances, at high risk of flashover during high winds and inclement weather.

7.02. DIESEL GENERATORS

Numerous rental generators are located at numerous locations around the site. We have noted the size and locations of these generators, and we have requested that YG provide us with an estimate of the monthly costs for these generators.

Based on our initial observations and metering results, we will be providing YG with some significantly more cost-effective options for providing reliable backup power at the site.

7.03. RECONNECTION OF THE FARO WORKSHOPS AND REMOVAL OF T3 TRANSFORMER

The 4160V branch circuit to the Faro Workshops recently experienced a fault situation during a lightning-storm that tripped off the main circuit to both the Faro Pit and the Van Gorda site.

The high-resistance 25A grounding system at T3 transformer, designed for use with mobile mining equipment, is still in use on that side of the network. This means that ground-faults on that circuit will not usually be cleared by fuses, and will be detected and tripped by the main circuit breaker at Electrical Room #1.

The fault was pinpointed to the 4160V Teck-cable where it terminates on a pot-head and enters the workshop building. Options for repair are:

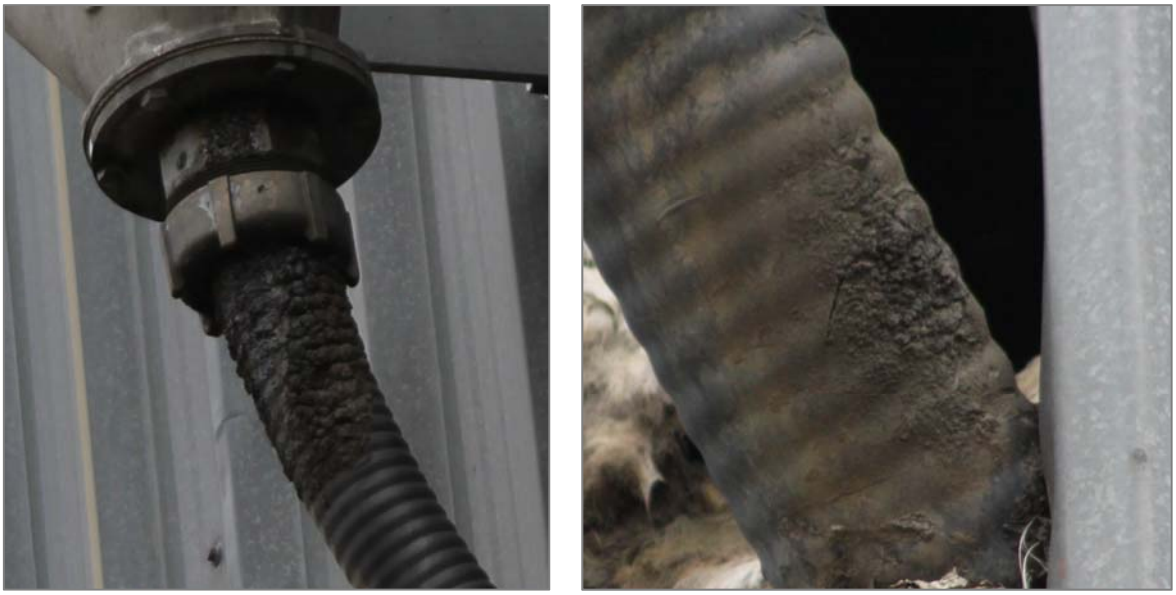
- Replace the 4160V Teck cable and install a new weatherproof pot-head termination, or,
- Install three new 100kVA step-down transformers on the overhead line, and run 600V triplex into the workshops, terminating to a 600V power cable to feed the existing distribution equipment in the building.

- This would bypass the existing oversized 1000kVA transformer inside the workshops which has a significant arc flash hazard associated with it.
- As the workshops are slated for eventual demolition, it would afford more flexibility in the decommissioning and demolition of the power system if the replacement transformers are located outside.

Additional cost estimates will be worked on in the coming phases of the project.

We will also be assessing options for the removal of T3 transformer and reconfiguring the 4160V grounding system on the Faro pit circuit.

Faulted 4160V Cable Entering the Faro Workshops



Close-up Photo's of Faulted 4160V Cable Entering the Faro Workshops

7.04. RECONNECTION OF THE MILLER SKID

The "Miller Skid" treatment facility is powered from an oversized 1000kVA transformer located in one of the old plant buildings that are slated for eventual demolition.

Power comes off the 4160V West-side power line and routes into the old plant building with a 4160V teck cable, feeds into a 1000kVA 4160:600V step-down transformer. Power from this transformer then routes through a series of obsolete switchgear cells and Motor Control Centers before going outside to feed the 200Hp VFD-driven pump.

We will be exploring options to circumvent the obsolete and oversized power equipment inside the old plant building, and replace with a cleaner 3 x100kVA pole-mounted solution.

7.05. OPTIONS FOR DECOMMISSIONG / MOVING THE MAIN SUBSTATIONS

We have gathered sufficient information at site to continue working on preliminary design concepts and cost estimates for relocating and/or decommissioning and replacing the various main substations.

We will also be providing options for optimizing the 69kV system that feeds the Van Gorda site.

7.06. OVERHEAD LINE ALONG NORTH SIDE OF GRUM PIT

YG had requested StruthersTech to review an earlier report by Golder, outlining concerns with power poles being close to the edge of the unstable pit walls.

We have inspected the area in question and found no immediate cause for concern. There is approximately 15m of clear space between the worst-case pole and the edge of the pit wall. Anything greater than 1.5m of undisturbed soil is sufficient for stability of the poles.

The eventual timing for decommissioning / removal of these poles depends on how quickly the pit walls are eroding. If they are eroding at a rate of 3m per year, for example, the poles should be moved within 3 years.

Note that this section of line is not in service, so could be decommissioned any time.

Other poles identified in the Golder report are disconnected from service and could also be removed at any time.

Worst-case distance from 4160V line to Grum pit-wall occurs on this particular pole, and is approximately 15m. (Optics in the photograph are somewhat deceiving). A closer view of the same pole is shown below. Note the size of the Engineer in the photograph for a reference scale:

7.07. ROSE CREEK OVERHEAD LINE SPAN

YG had requested that StruthersTech more closely review the options for re-routing or re-spanning the 69kV line where a major excavation is planned for the North Fork Rose Creek Diversion Project.

After inspecting the site in person, we believe the most straightforward and cost effective solution is to simply install an elevated span, 230m long, directly over the planned working area. This will require a two-pole structure using 90' poles on each side, very similar to the two-pole structures that deliver the 138kV YEC power to the site.

The only significant drawback to this option is that the width of the structures will likely cut the haul road from two-lanes to single-lanes at this location.

StruthersTech will develop a preliminary design to confirm the overall dimensions and design parameters, and determine the costing for this solution.

7.08. 69KV LINE REPAIRS

YG has expressed concern about the line-to-ground clearances of the 69kV line on the haul road between the Faro and Van Gorda Sites. Specifically of concern are the first few kilometers at the Faro mine side, where waste rock has been piled up alongside the transmission line right of way.

During our first visit to site, a number of clearance measurements were made using a non-contact ultrasonic clearance meter.

- In many of the areas of concern, the waste-rock was found to be offset from the transmission line, resulting in line to ground clearances that are actually well within the allowable limits.
- Many of the waste rock piles provide an effective barrier to vehicles and equipment from encroaching on the line clearances. In many locations it would be counter-productive to remove the waste-rock piles if improved safety is to be the end-goal.
- Our initial impression is that only a limited number of spans in the first few kilometers have non-compliant clearances. The vast majority of the line is clearly compliant.
- We will complete a thorough survey of every span during our second trip to site.
- Some vegetation brushing and clearing is recommended in the latter 2/3 of the line (toward Van Gorda), as vegetation is beginning to encroach on line clearances and will present a fire hazard if left unchecked. (Especially important given the ungrounded nature of the line, discussed earlier)

7.09. REPLACEMENT ASSET PLANNING

To better quantify the remaining life-span of major electrical assets, additional testing is required. Some of this can be performed during our return trip to the site:

- Transformer oil sampling (usually requires no outage)
- Transformer electrical testing (requires an outage and additional test equipment)
- E-House #1 and #2 Switchgear Testing (spare breakers may be tested without an outage, active breakers and protection relays must be taken out of service.)

Based on our initial visual inspections, we believe the likely results will be:

- Most transformers should be in acceptable condition to last another 10 years, subject to additional testing and maintenance.

  An oil test is one of the fastest and least expensive methods of getting an overall picture of the transformers' health. It also allows for the detection of PCB's.

- The obsolete 4160V switchgear units are in need of replacement and pose an elevated safety risk with significant reliability concerns the longer they remain in service.
- Other assets are relatively inexpensive and are easy to replace at short notice. (Overhead line equipment, small transformers and low voltage panelboards)